

MECHANICAL ENGINEERING
(Paper I)

Time Allowed : Three Hours	Maximum Marks : 300
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QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:

- (a) The ball bearings are to be selected for an application in which the radial load is 2 kN during 90 per cent of the time and 8 kN during the remaining 10 per cent. The shaft is to rotate at 150 rpm. Determine the minimum value of the basic dynamic load rating for 5000 hours of operation with not more than 10 per cent failures. **20**

- (b) The figure given below shows the state of stress at a point namely 30 N/mm^2 tensile in X-direction. 20 N/mm^2 tensile in Y-direction and a shear stress of 50 N/mm^2 . Find the location of the principal planes, principal stresses and the maximum shear stress graphically or otherwise. **20**

[Figure: Square element. Right face: normal stress arrow pointing right (outward) labelled 30 N/mm^2 and shear arrow pointing up labelled 50 N/mm^2 . Left face: normal stress arrow pointing left (outward) labelled 30 N/mm^2 and shear arrow pointing down, labelled 30 N/mm^2 [?]. Top face: normal stress arrow pointing up (outward) labelled 20 N/mm^2 and shear arrow pointing right labelled 30 N/mm^2 [?]. Bottom face: normal stress arrow pointing down (outward) labelled 20 N/mm^2 and shear arrow pointing left labelled 50 N/mm^2 . (The text gives the shear stress as 50 N/mm^2 ; the shear labels on the left and top faces read 30 in the source.)]

- (c) (i) Derive a formula for increase in volume of a thin metallic sphere when it is subjected to an internal pressure p . (ii) A thin spherical shell of copper has a diameter of 400 mm and a wall thickness of 2 mm and is just full of water at atmospheric pressure. Calculate the volume of water pumped in to raise the inside pressure to 1.5 N/mm^2 . The modulus of elasticity for copper is 1×10 [?] N/mm^2 , K (Bulk Modulus) is 2.5×10 [?] N/mm^2 and Poisson's ratio is 0.25. **20**
- (d) What are the defects developed by the components of steel of any machine during heat treatment operation? Give the causes for such defects and explain the remedies taken. **20**

2. (a) A machine of mass 68 kg is mounted on springs of combined stiffness k 1100 N/mm with an assumed damping factor of 0.2. A piston within the machine of mass 2 kg has reciprocating motion with a stroke of 75 mm and a speed of 3000 rpm. Assuming the motion of the piston to be simple harmonic, determine (i) the amplitude of vibration of the machine (ii) the phase angle with respect to the existing force and (iii) the transmissibility and the force transmitted to the foundation. **30**
- (b) A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at a maximum speed of 225 rpm. Radius of gyration of the flywheel is 0.5 m.

The press punches 70 holes per hour; each punching operation takes 2 seconds and requires 15 kN-m of energy. Find the power of the motor and the minimum weight of the flywheel if the speed of the same is not to fall below 200 rpm. **30**

3. (a) In an epicyclic gear train as shown in the figure given below, the arm A is fixed to the shaft S. The wheel having 100 teeth rotates freely on the shaft S and the wheel F with 150 teeth is separately driven. If the arm A runs at 200 rpm and the wheel F at 100 rpm in the same direction, find (i) Number of teeth on wheel C and (ii) Speed of wheel B. **30**

[Figure: Epicyclic gear train drawn as concentric circles about the shaft S at the centre: an inner wheel B mounted on S, an outer annular (internal) wheel F, and two planet wheels C (one at the top, one at the bottom) meshing between B and F; the arm A is a vertical bar through the centre S carrying the two planets C at its ends.]

- (b) A 150 mm diameter shaft supporting a load of 10 kN has a speed of 1500 rpm. The shaft runs in a bearing whose length is 1.5 times the shaft diameter. If the diametral clearance of the bearing is 0.15 mm and the absolute viscosity of the oil at the operating temperature is 11 centipoises find the power wasted in friction. **30**
4. (a) Differentiate between (i) Solid solution and Eutectoid and (ii) Eutectic and Eutectoid
- (b) (i) What are ceramics? How are they classified? (ii) Explain (a) Silicates (b) Vitreous structure (c) Chain structure and (d) Sheet structure as applied to engineering materials. **20**
- (c) Explain the various alloys of copper giving the details of composition of each alloy. **20**

SECTION 'B'

5. Answer any three of the following:

- (a) The assembly line for small tricycles has the following work elements identified and the sequence indicated **20**

Work element	Immediate Predecessor of the work element	Work element time (in minutes)
A	Nil	5
B	Nil	3
C	B	3
D	A, C	2
E	D	2
F	D	3
G	E, F	5
H	E, F	8
I	G, H	1
J	I	1

For the above (i) prepare the precedence diagram. (ii) using Helgeson and Bimic or any other heuristic method, show a feasible grouping of the work elements and number of workstations, assuming that the cycle time of one assembly is 8 minutes. (iii) calculate the balance-delay for your arrangement.

- (b) With sketch, show basic surface characteristic of roughness and waviness. What do a, b, c, d, e and f shown in the typical specification illustration given below represent? Also indicate the values of surface roughness represented by the following triangles Δ , $\Delta\Delta$, $\Delta\Delta\Delta$, $\Delta\Delta\Delta\Delta$. **20**

[Figure: Surface texture (machining) symbol standing on a hatched workpiece surface: a check-mark (V) symbol whose longer right arm extends upward and then horizontally to the right. Label "a ~ b" above the horizontal extension, "e" below the horizontal extension, "c" and "d" (c above d) to the left of the V near its short left arm, and "⊥ f" to the right of the V, just above the surface.]

- (c) A process was set to produce rivets of 10 mm length. The first 32 pieces made by the process were found to have the following lengths (in mm) 9.9, 10.0, 10.0, 9.9, 9.9, 9.9, 10.0, 10.0, 10.1, 10.1, 10.0, 10.0, 9.9, 10.1, 10.1, 9.9, 9.9, 10.1, 10.0, 10.1, 10.0, 9.9, 9.9, 9.9, 10.1, 10.0, 10.0, 10.1, 10.0,

10.0, 10.0, (i) Plot $\bar{X}$ and R control chart for the process, taking data for A_2 , D_3 and D_4 from the following table **20**

No. of observations in the sample	2	3	4	5	6
A_2	1.88	1.023	0.729	0.577	0.483
D_3	0	0	0	0	0
D_4	3.276	2.575	2.282	2.115	2.004

(ii) If the process is not under statistical control, discuss what steps should be taken to make the control chart viable?

- (d) A ball at the end of a very long pendulum can be assumed to move linearly between two metallic plates at a fixed distance apart. The inner distance between the plates is slightly more than the diameter of the pendulum bob which is spherical leaving clearance on the left or on the right. If the plates move in simple harmonic motion, the amplitude being very small, the bob may touch the left or the right side plate or it may not touch any, at any instant. If the bob touches the left plate, equation A is governed while if it touches the right plate, equation B is governed. If there is no contact by the bob on any of the plates, then equation C is governed. Write a flow chart in FORTRAN for the motion of the bob. **20**

6. (a)(i) What are the advantages of laser beam machining in respect of the following Material removal mechanism, energy source, Energy transfer media, potential, current, power, gap and applications. **15**

- (a)(ii) What is high energy rate forming? Discuss the theory of high energy metal forming. What are the advantages and limitations of high velocity forming? **15**

- (b) With the help of sketches, show the degrees of freedom. a work-piece in space possesses and how nine degrees of these freedoms can be restricted with the help of 6 pins. How are the remaining three degrees of freedom restricted when holding the work-piece for machining? **30**

7. (a) In a stop watch time study, the actual readings in minutes recorded for an element are 0.05, 0.06, 0.05, 0.05, 0.05, 0.06, 0.06, 0.05, 0.06, 0.06, 0.06, 0.06, 0.05, 0.05, 0.06 and 0.05. (i) Have sufficient number of readings been taken for 95% confidence level and $\pm 5\%$ accuracy? (ii) If the rating is 120%, what would be the normal time for the element? (iii) What would be the standard time for the element if the personal needs allowance; fatigue allowance and contingency allowance are 5%, 6% and 5% respectively? (iv) What is the purpose of providing contingency allowance? Give two examples. **30**

- (b) The demand for a newly introduced luxury car has been shown below. The experts forecasted a sale of 100 cars for the month of March. With a smoothing constant of 0.15 and using first order exponential smoothing what is the forecast for the month of August? Also calculate MAD and Bias and give your comments on the same: **30**

Month	Actual Demand
March	150
April	200
May	100
June	50
July	150

8. (a) Distinguish between the situations where transportation models and assignment models may be used. A job shop type machine tool company employs a team of 4 assemblers with varying capabilities. It has received an urgent order to supply 4 assemblies as soon as possible and decides to assign one assembly to each assembler. Assign the assemblies to assemblers so that the total cost is minimized. The following matrix shows the cost of assembly by each assembler in hundreds of rupees. Also calculate the total cost of the 4 assemblies **30**

Cost matrix (columns: Assembler; rows: Assembly):

5	7	6	8
7	4	4	9
3	6	9	6 [?]
8	2	6	1

- (b)** Name any five electrodes (tools) materials used in EDM (Electric Discharge Machining). Give the advantages and disadvantages of graphite as a tool material. Also define flushing and state its purpose. Describe with sketches the various types of flushing used in EDM. **30**

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